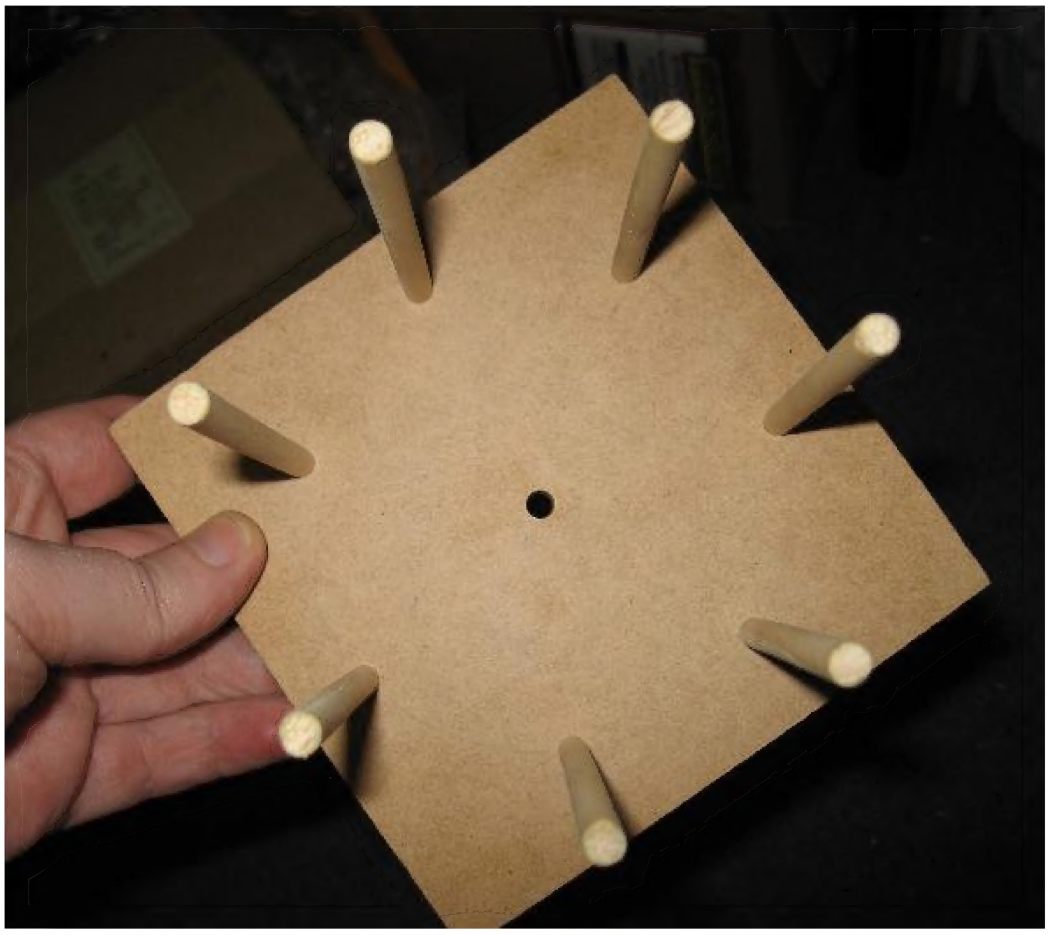
Basket-Weave Coil Jig

2008-10-25

A mate in Queensland was discussing building a crystal set with his daughter to help introduce her to homebrew electronics. The discussion kicked off some thoughts and eventually modelling of crystal sets with Spice... The Q of the resonator being the major figure of merit I wanted to attack first, research into high-Q coils at MF brought up the old spider web and basket weave geometries to decrease distributed capacitance and the proximity effect. I had to try this in practice and see just how much of a difference it made.

To this end I built a quick jig for winding basket weave coils. The base is just a 5" square piece of MDF. I wrote a calculator to help construct the dowel spacings around the 100 mm diameter circle. This particular jig has just 7 pins (it must be an odd number), each 6 mm in diameter, which is a good fit to common soda straws - helpful for keeping the coil in shape after it has been removed from the jig.



The first coil was wound with 1 mm diameter multi-strand zip-cord from the junkbox. A length of about 8.5 metres, initially used as part of an antenna, it had been corroded at the ends and replaced. 27 turns were made with the available length, tied together with some cotton string. The inductance was measured at 55.8 uH with a distributed capacitance of 4.3 pF. Q at 2 MHz was 149 and at 1 MHz was 151. Not very good but considering the wire used this is to be expected.

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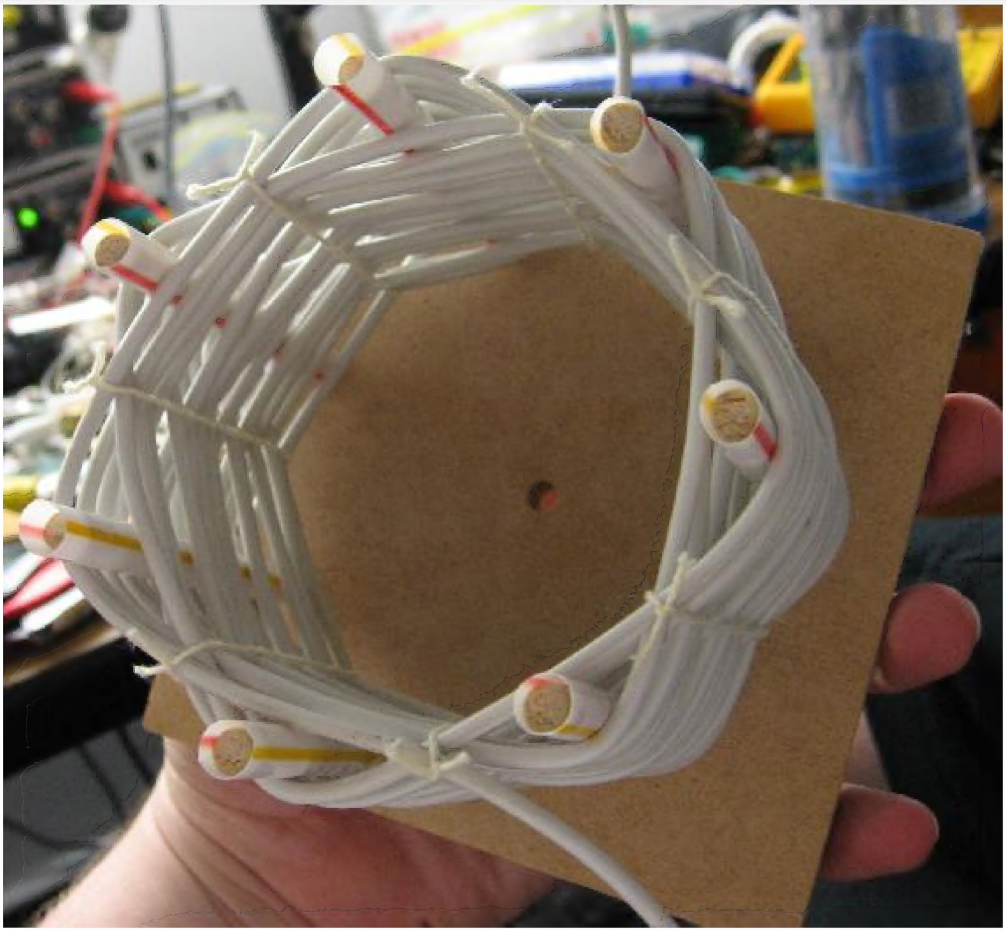
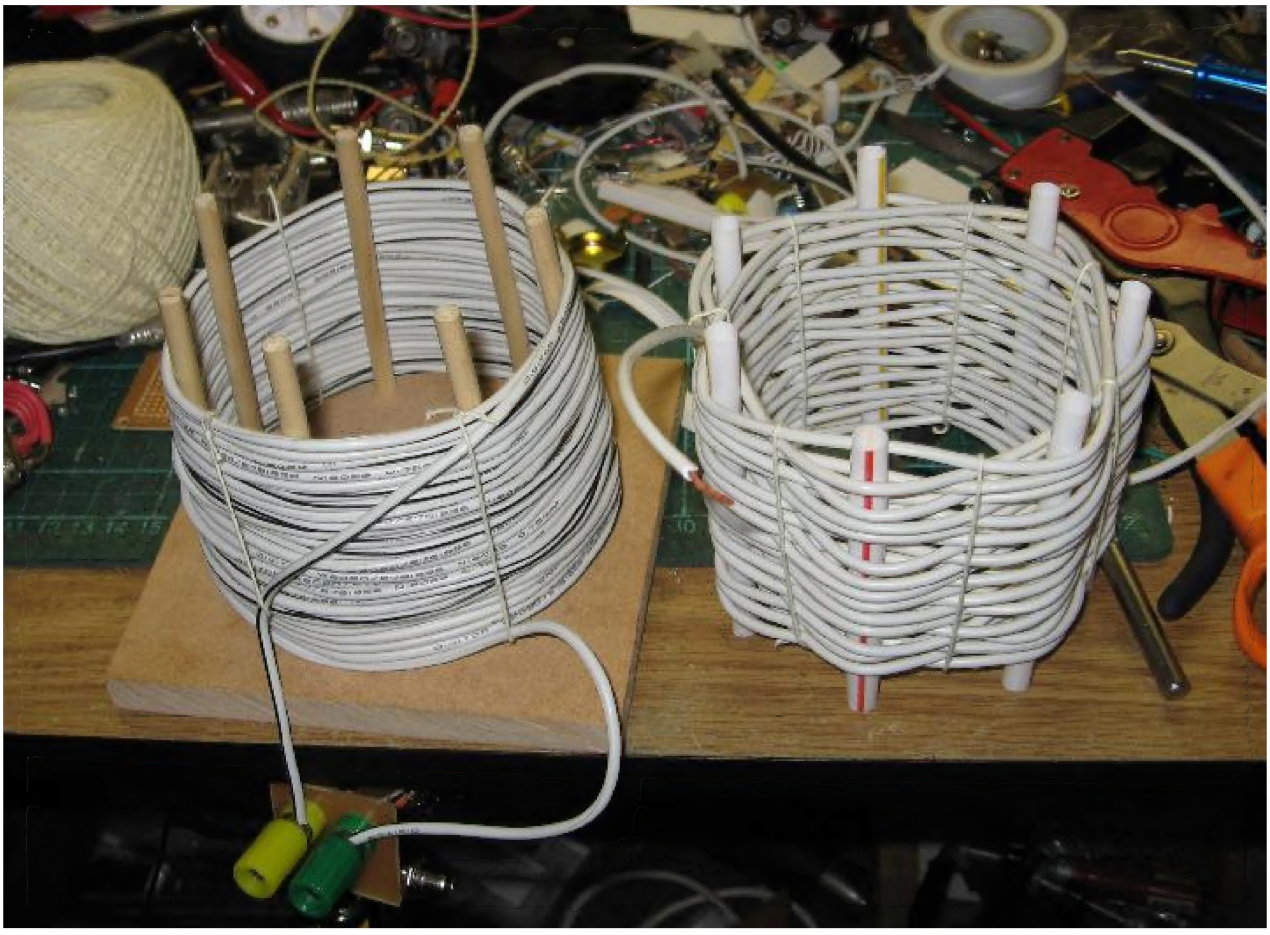


For comparison the other half of the same dipole was wound over the outside of the jig pins, giving an inductance of 62.1 uH and a distributed capacitance of 4.1 pF. The Qs where 165 at 2 MHz and 167 and 1 MHz. That didn't seem right at all, better Q and lower distributed capacitance. I'd clearly not taken enough care with the measurements or the corrosion of the wires had migrated unevenly and further into the cable than I had discarded.



To make sure I wasn't going insane I bunched up the "close wound" coil into a doughnut-shaped bundle and repeated the

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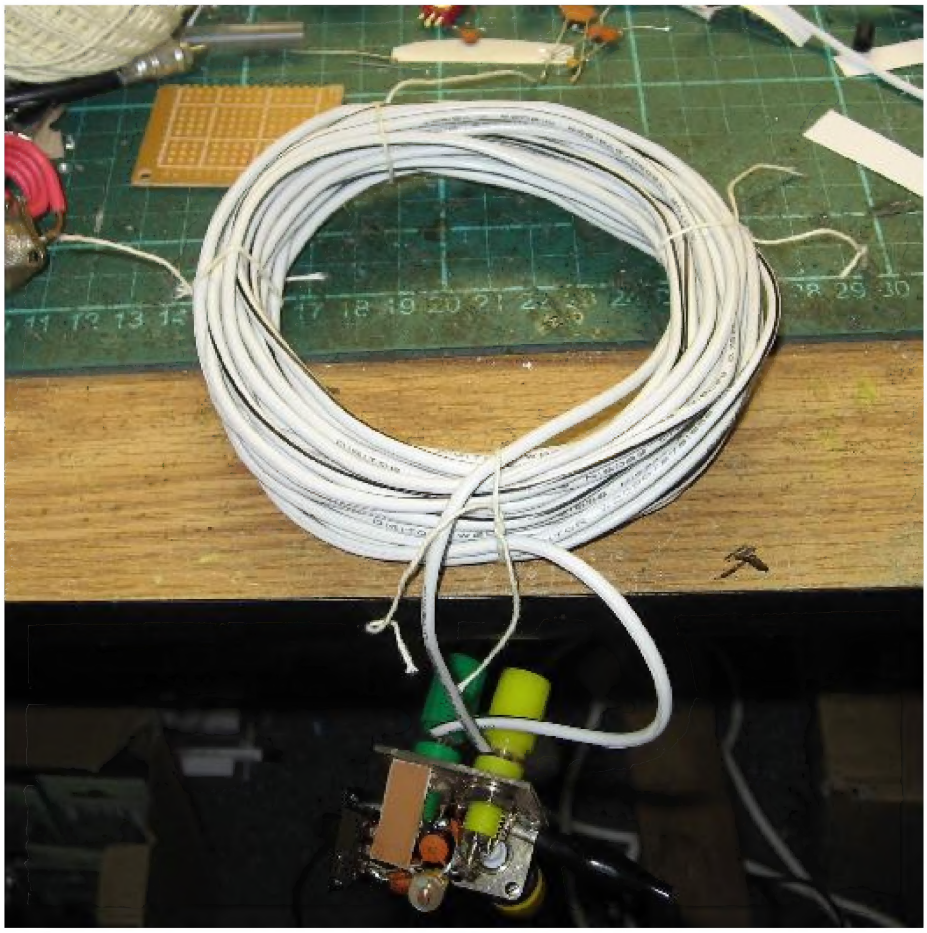
tightened up the bundle by tying more strings around it. Still it didn't leave me feeling very confident that my choice of the junk-box zip-cord wire was representative. I initially thought it was the worst choice and would make an interesting lower bound - that it did, but its properties also probably hid any real advantage of the basket weave. Its jacketing definitely makes a coil much longer for the same inductance because it effectively spaces it out for you. The dielectric properties of the jacket are also an unknown.



Frustrated by this likely invalid result I decided to go smaller. A 5 pin basket weave jig was constructed using BBQ kebab skewers and a 25 ml syringe barrel (about 20 mm in diameter). Using this jig and 0.5 mm enamelled copper wire a quite artistic pentogram-like coil was wound, giving 3.3 uH of inductance. My initial resonance measurements had sufficient error to cause -ve distributed capacitance results in my calculator - however it gave an accurate estimate of the true inductance and placed the distributed capacitance in the 0.5 - 1 pF region. The Q at 8.8 MHz was 176 and at 4.4 MHz 96. Self-resonance was measured using my tone dipper and the frequency measured to better than 1% by comparison against the signal generator and counter; 87.7 MHz which put the distributed capacitance at almost exactly 1 pF.

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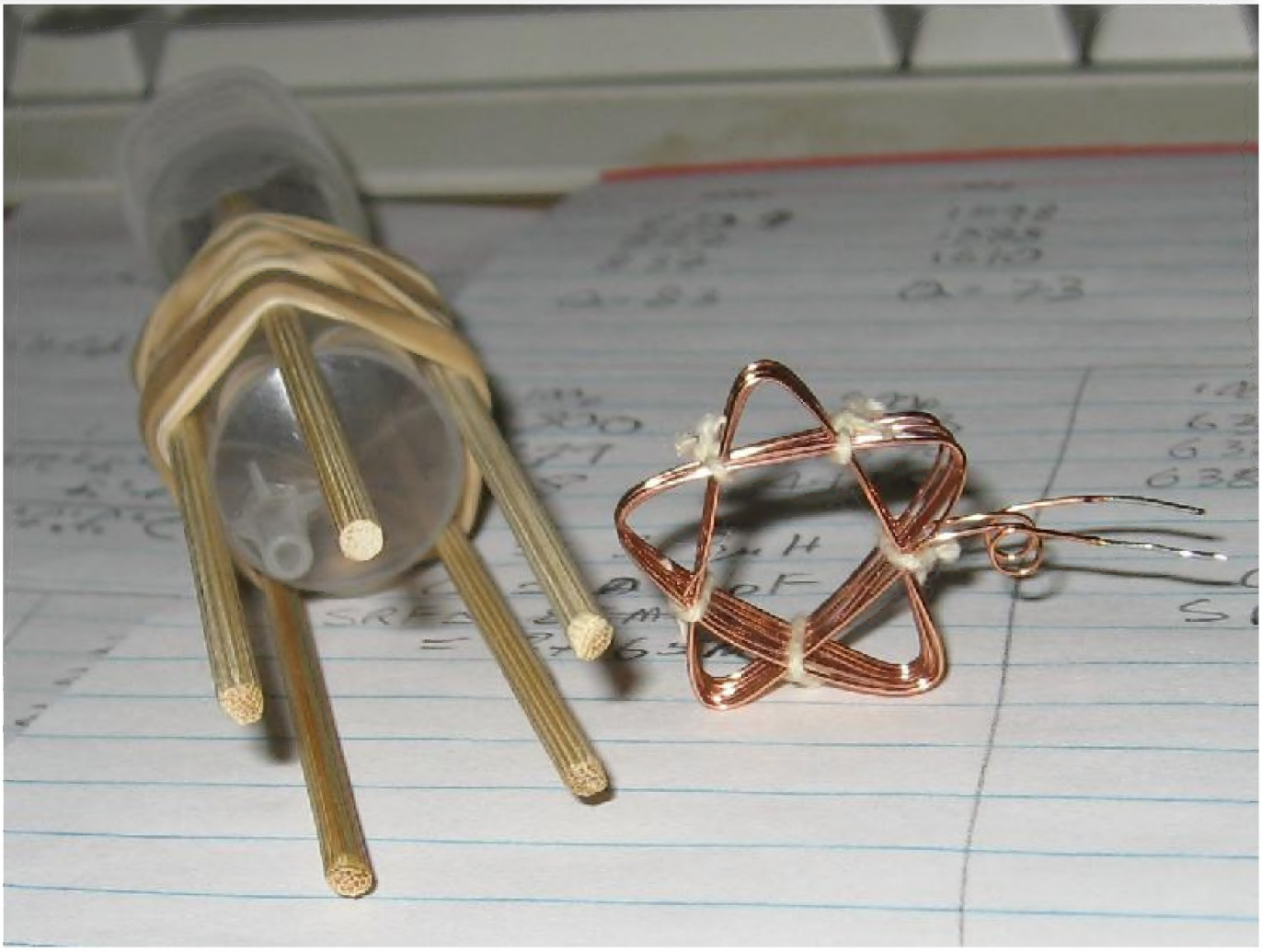

For comparison purposes a close-wound solenoidal coil was constructed of similar diameter and turn count using the same 0.5 mm wire. I was shooting of the same inductance, but overshot by almost twice at 6.3 uH. I guess leakage from the very non-circular cross-section of the basket weave coil is significant - the value estimated by the coil calculator is close to that for the solenoidal coil, but even reduction based on the approximate cross-sectional area still over-estimates the inductance a bit. I guess it is a bit like having two mutually coupled coils of triangular cross-section in series with the turns interleaved out of alignment. The solenoidal coil distributed capacitance was also lost in the initial resonance measurement error (considering the test fixture used is based on 100 pF and 400 pF caps trimmed to 1% and the distributed capacitance is about 1% of the smaller one this is not surprising! I'm lucky to measure anything except frequency to within 1%.). Self-resonance was measured in the same manner as for the basket coil and at 57.6 MHz gives a distributed capacitance of about 1.2 pF. The Q at 6.3 MHz was 114 and at 3.2 MHz 85.5.

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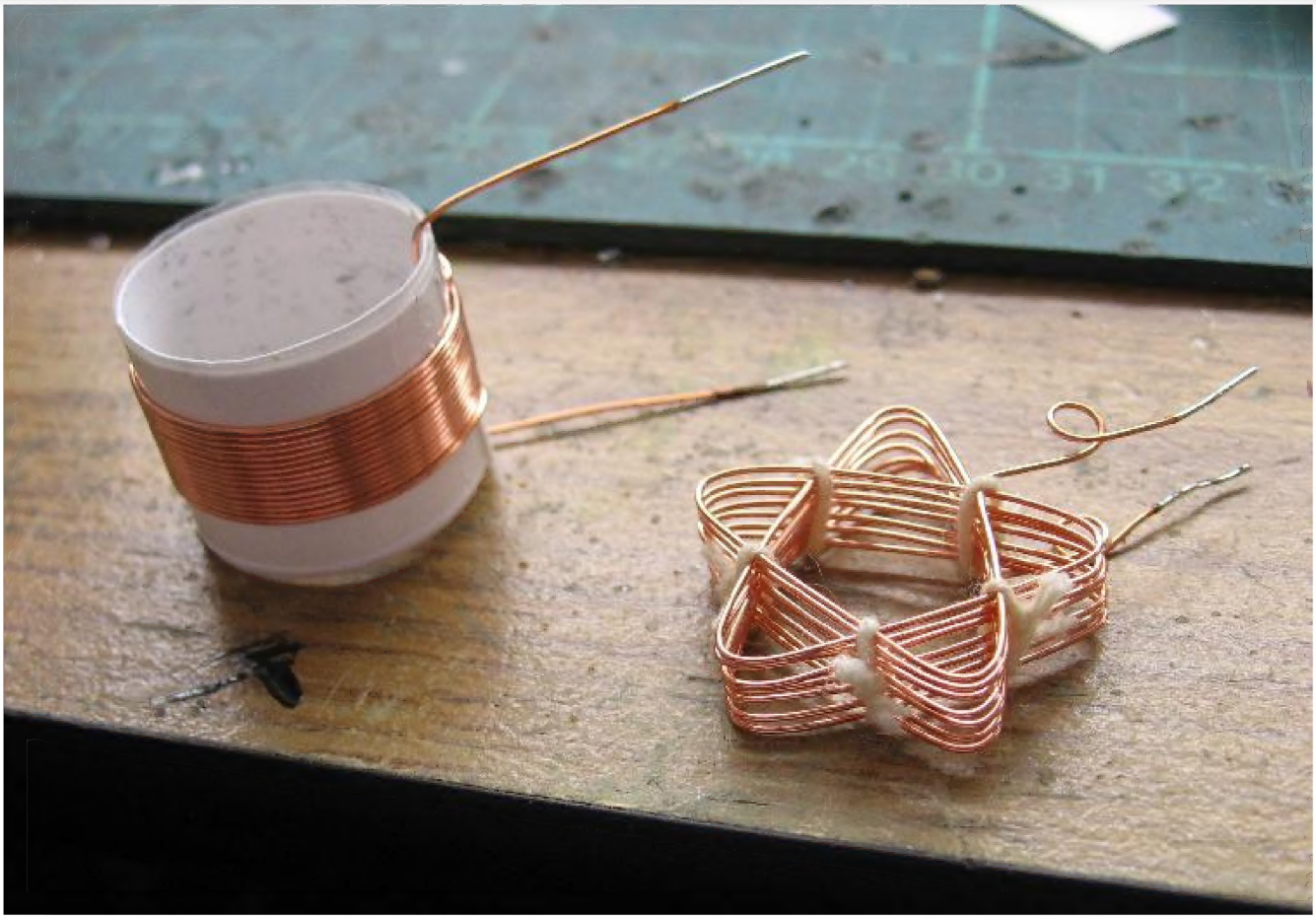

Also for comparison purposed a "long-thin" solenoid was wound on a 8 mm soda straw with 0.5 mm wire. Also shooting for about the same inductance I got 7 uH and didn't bother to remove turns to bring it back to ~ 6.3 uH. Its Qs were 63 at 3 MHz and 91 at 6 MHz. Not very impressive and worse than both previous coils on a root-frequency basis. The SRF was 78.3 MHz, quite impressive for a 7 uH inductor, which is about 580 fF of distributed capacitance! Around half that of the basket-weave coil and twice the inductance. This follows conventional wisdom that "flat" coils have more capacitance and a lower SRF than long thin ones, which in turn tend to make better chokes.

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It is interesting to note that the slope of the Q change with root-frequency is much shallower for the basket-weave coil, suggesting perhaps its proximity losses are smaller. Only 2 data points for each coil is insufficient to say this, but it seems like the proximity effect reduction is visible in the numbers. More data points for each coil and comparison with a space-wound solenoidal coil would be a worth-while investigation. Measuring Q is laborious with the current jig and manual data reduction (3 dB points method - although I have recently constructed a 3 dB switched attenuator to make the process slightly more pleasant). A direct-reading Q meter would speed things enormously and will likely feature shortly.

The wire used in the larger coil is probably the reason the measurements were odd, in a way it is already spaced - by its jacket. Results with the smaller coils do look interesting. Once I have Q-measurement worked out I'll revisit this, and try using better wire, including some Litz wire I have (unfortunately not especially high-count). Litz wire could be homebrewed, but the machine to do it would be quite non-trivial, I could imagine doing it in hexagon-number (ie 7) wires at a time, then spinning 7 bundles of 7 together, etc. I think tension control would be the hard part, otherwise I'd invest in a few kg of very fine wire and give it a go - Litz wire is insanely expensive online and I haven't found an Australian supplier of it yet.

11 comments.

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